Long term data records of stratospheric composition from the GOZCARDS Project: Variations in HCl, O_3, and H_2O

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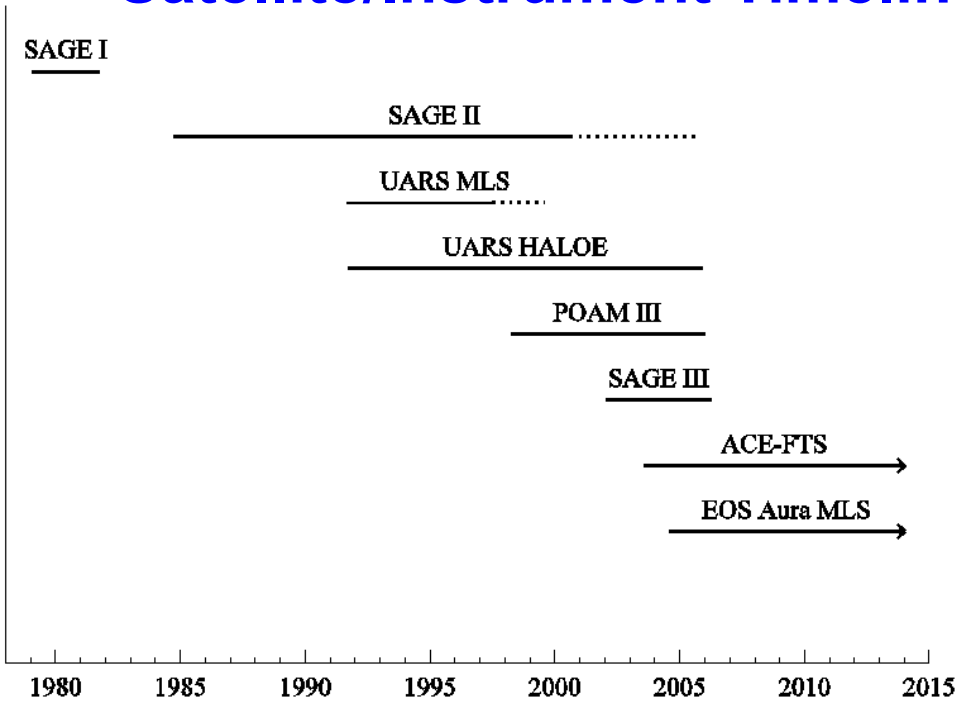
GOZCARDS: Global OZone Chemistry And Related trace gas Data records for the Stratosphere

part of the NASA MEaSUREs program

Aura Science Team Meeting, Oct. 1-3, 2012, Pasadena, CA

Satellite/Instrument Timeline and data versions



Timeline of satellite missions and instruments considered for the GOZCARDS project and the creation of a stratospheric composition Earth System Data Record (ESDR).

Data Versions
(for creating merged data records)

	O_3	H_2O	HCl
SAGE I	5.9	-	-
SAGE II	6.2	-	-
UARS MLS	5	6	-
HALOE	19	19	19
ACE-FTS	2.2u	2.2	2.2
Aura MLS	2.2	3.3	3.3

Common Grids

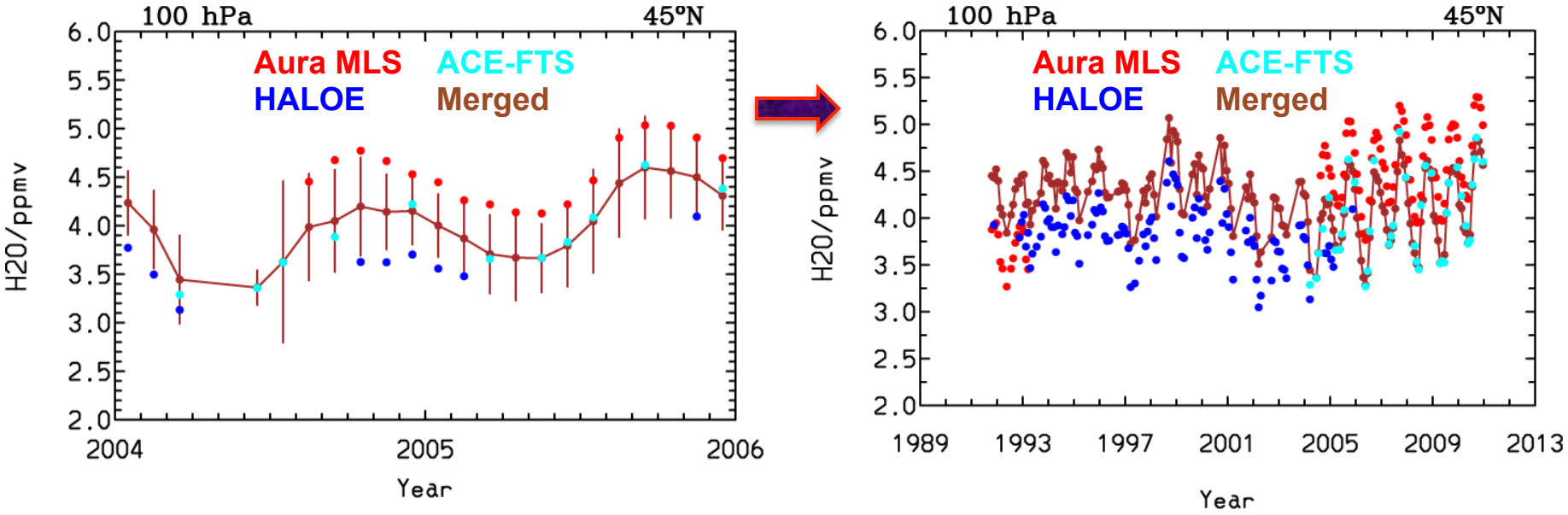
– Mixing ratios (time, lat., p)
- Monthly zonal averages
- 10 degree latitude bins
- $p(i)= 1000/10^{(-i/6)}$ i=0, 1, 2, .. (same as UARS pressure grid)

netCDF source files & merged files

> include mean values, but also std. deviations, std. errors,
+ info on local time, SZA, days used each month
+ offsets applied to each source dataset

GOZCARDS methodology for merging datasets (H_2O, HCl)

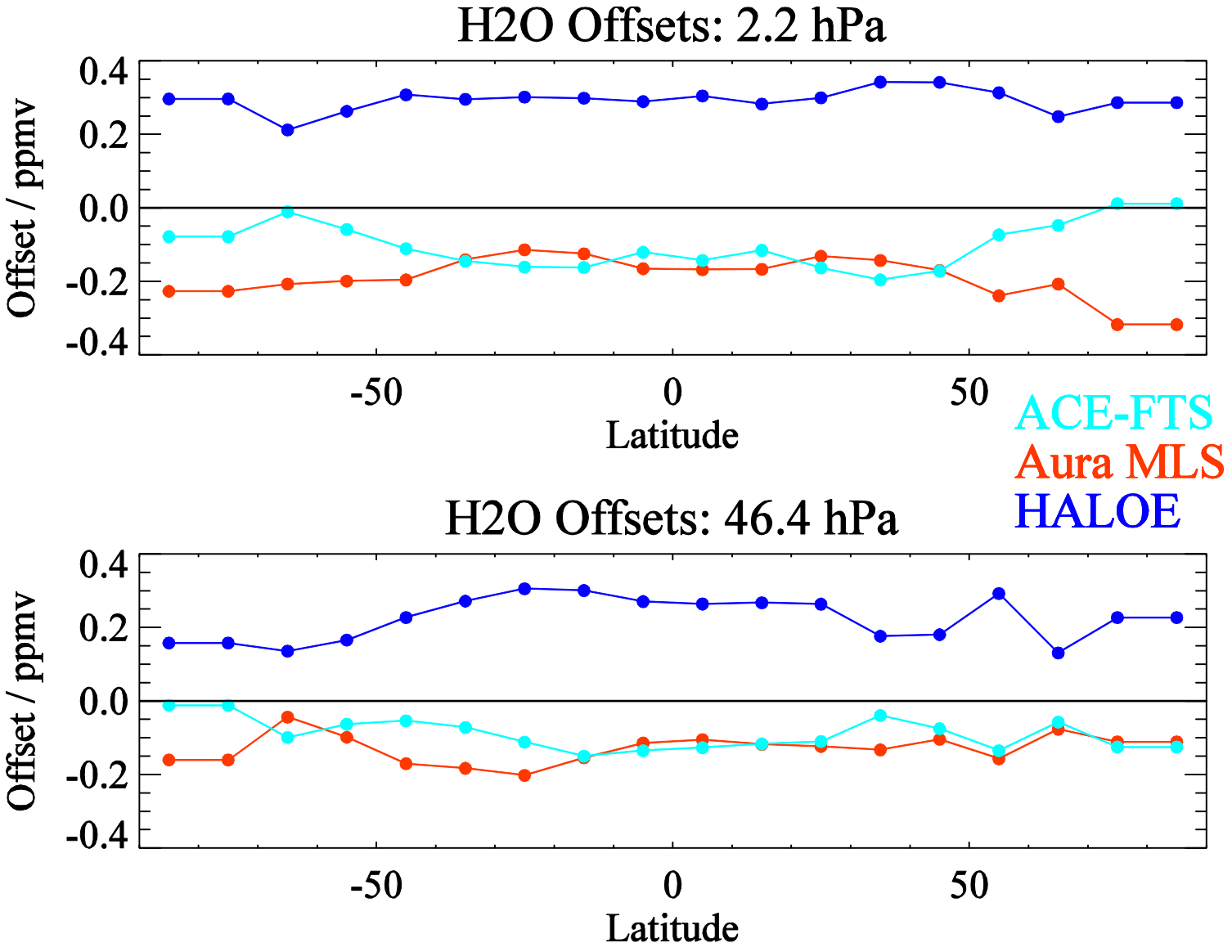
- Merging process uses a bias correction method to tie time series together into one longer-term series
  - > obtain average offsets during overlap time period(s)
  - > make use of the good temporal coverage provided by MLS, and iterate using ACE-FTS and HALOE consecutively (weighting = 1/3 for each)
  - > result (in H_2O example below) is equivalent to using 3-way average during overlap period



Methodology for HCl and H_2O is basically identical

(but for H_2O, add UARS MLS as an extra step; also, ignore Aura MLS HCl for p < 10 hPa.)

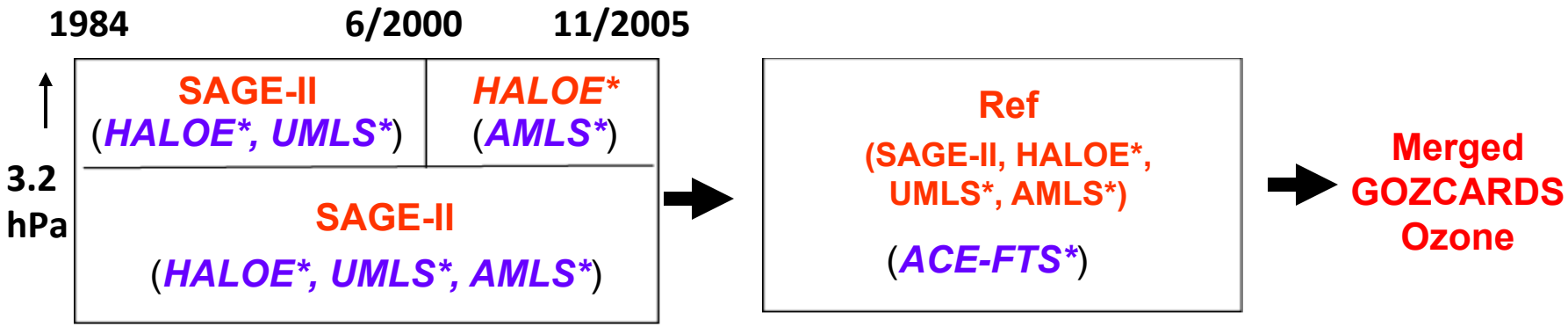
Examples: GOZCARDS Offsets for H_2O



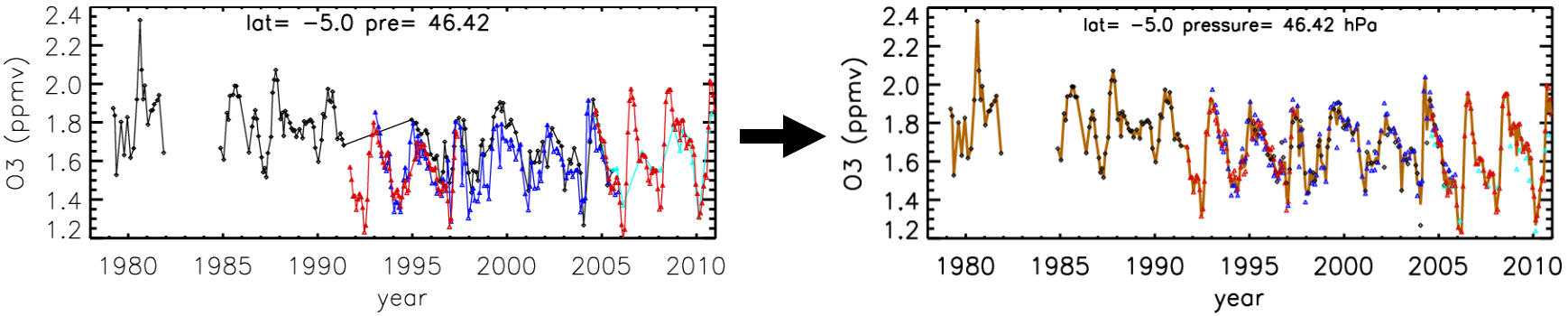
GOZCARDS methodology for O_3

- For each individual satellite dataset, first calculate **monthly zonal means** (in ppmv) **for each 10° latitude bin and pressure level** (~2.5 km spacing) with careful screenings.

- Adjust datasets to a **reference level** **that is equal to or based on SAGE-II average**
  > then, average the adjusted (and collocated) datasets to derive a merged ozone record.



- **Note: above 3.2 hPa,** use **adjusted HALOE (HALOE*)** instead of SAGE-II as reference, due to anomalous NCEP temperature trends after June 2000 (see next page)

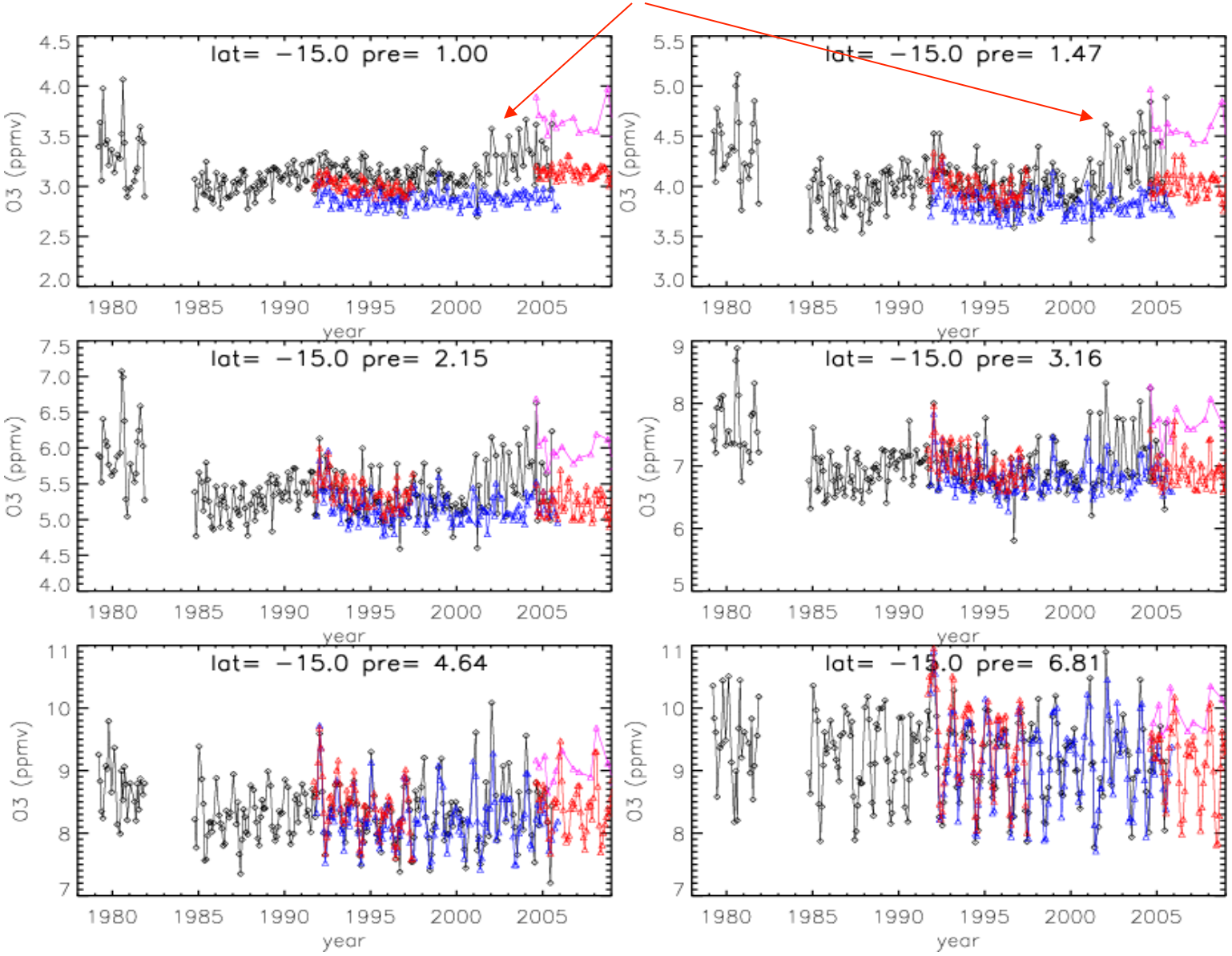


(Left). **O_3 from SAGE-I/II**, **HALOE**, **UMLS/AMLS**, and **ACE-FTS** between 0 and 10°S at 46.4 hPa.
(Right). Adjusted source datasets and merged time series for O_3 in same lat./p bin as left panel.

Monthly zonal mean ozone from **SAGE**, **HALOE**, **MLS**, and **ACE**

- Issue (mainly for upper strat. after mid-2000) [*McLinden et al*., 2011]

T-related (NCEP) drifts impact ozone time series for SAGE II data converted to VMR/p grid

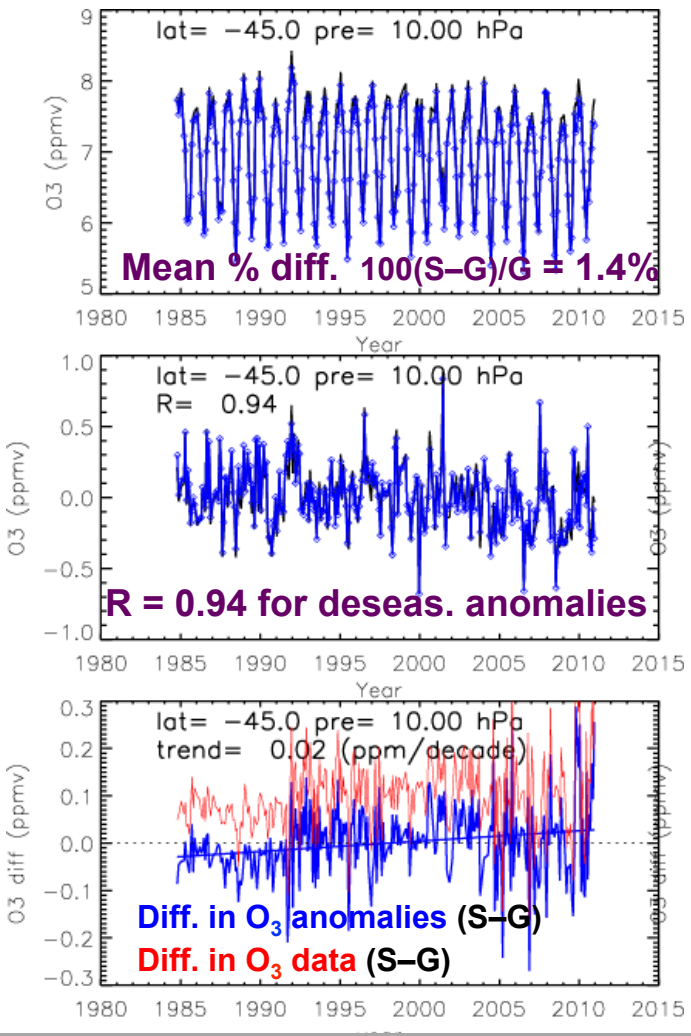


Comparisons between GOZCARDS and SWOOSH

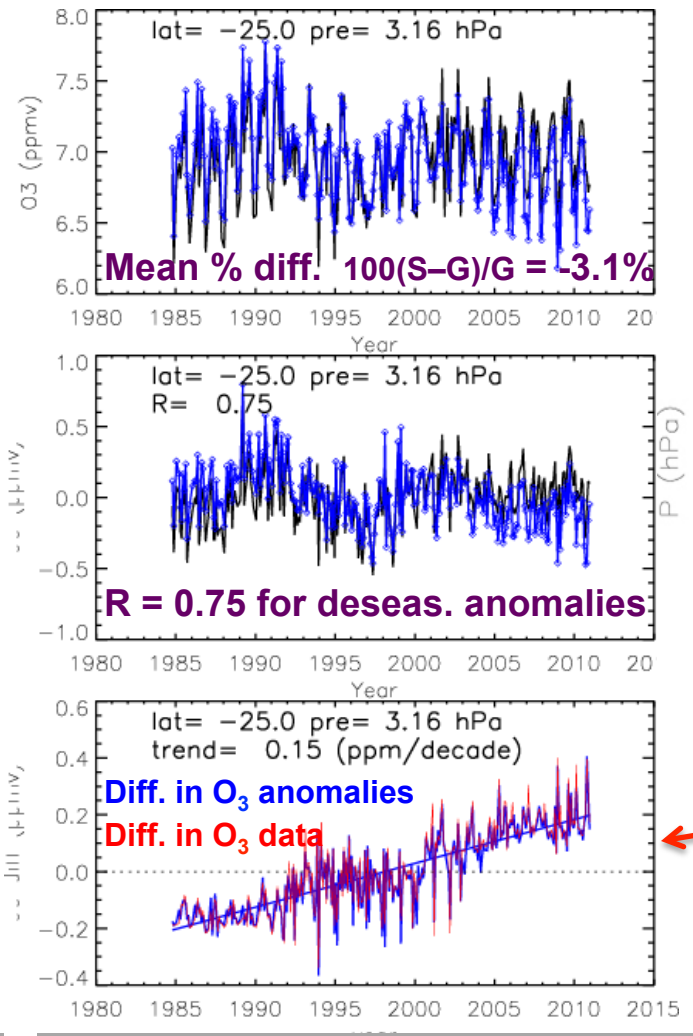
- The **S**tratospheric **W**ater and **O**z**O**ne **S**atellite **H**omogenized **(SWOOSH)** database (*from preliminary version - Sean Davis, Karen Rosenlof, NOAA*)
  - **Datasets used**
    - SAGE-II, UARS MLS, HALOE, Aura-MLS
      > notes: SAGE II H_2O not used in GOZCARDS (channel drift issue concerns)
      UARS MLS not (yet) used in SWOOSH O_3 data
  - **Report monthly zonal means**
    (both latitude/pressure and equivalent latitude/PV surfaces)
    - Volume mixing ratios (monthly means)
      - 18 latitude bins (every 10°) [also report data in 2.5°bins]
      - Aura MLS (v3.3) pressure levels
  - **Merging method for SWOOSH**
    - **Use Aura-MLS as reference**
      > GOZCARDS uses SAGE II for O_3 and avg [HALOE, AMLS, ACE-FTS] for H_2O
    - Calculate offsets based on collocated profile pairs (within latitude bins)
- Differences above (+ other diffs.) in source datasets and merging methods
  → we do not expect a "perfect match" for GOZCARDS versus SWOOSH
  - but this is a **useful cross-check for O_3 and H_2O results**
    (for both the GOZCARDS and SWOOSH teams)

O_3: Comparisons between GOZCARDS and SWOOSH (V2.0) (1984-2010)

SWOOSH and **GOZCARDS** O_3 series at 10 hPa for 40S-50S

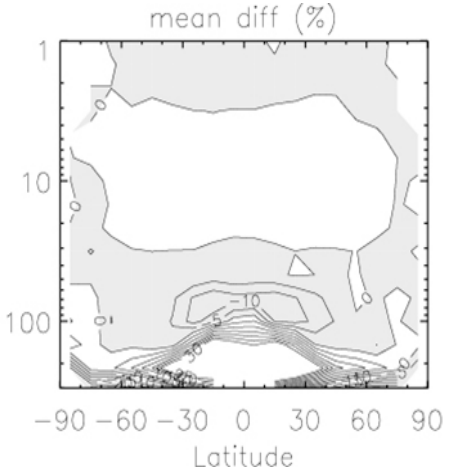


SWOOSH and **GOZCARDS** O_3 series at 3.1 hPa for 20S-30S



Mean diffs. are < 5% in most of stratosphere

- larger % diff. in tropical UTLS (where SAGE II & Aura MLS differ more)



Trend differences in upper strat. arise from

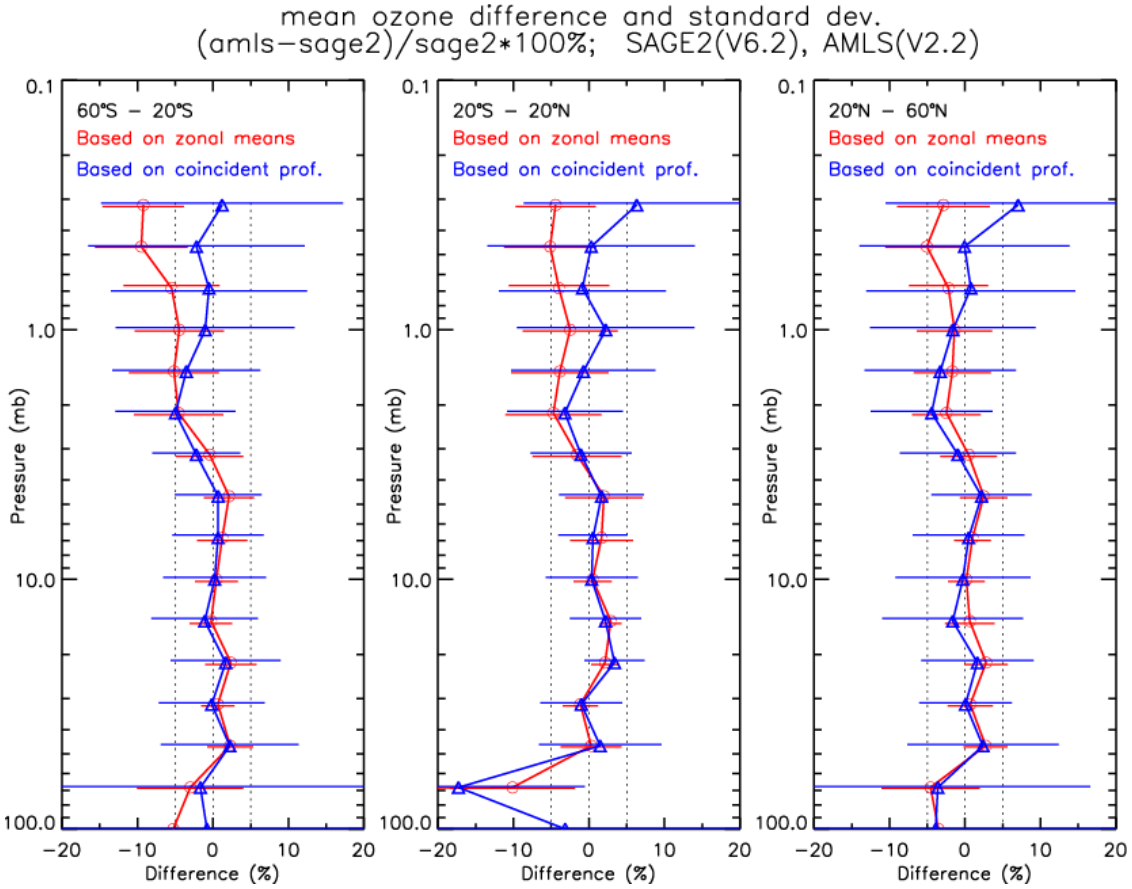
- different source data & references
- different treatment of SAGE II after mid-2000.

relative trend in differences 0.02 ppmv/decade (~ 0.3%/decade)

relative trend in differences: 0.15 ppmv/decade (~2%/decade)

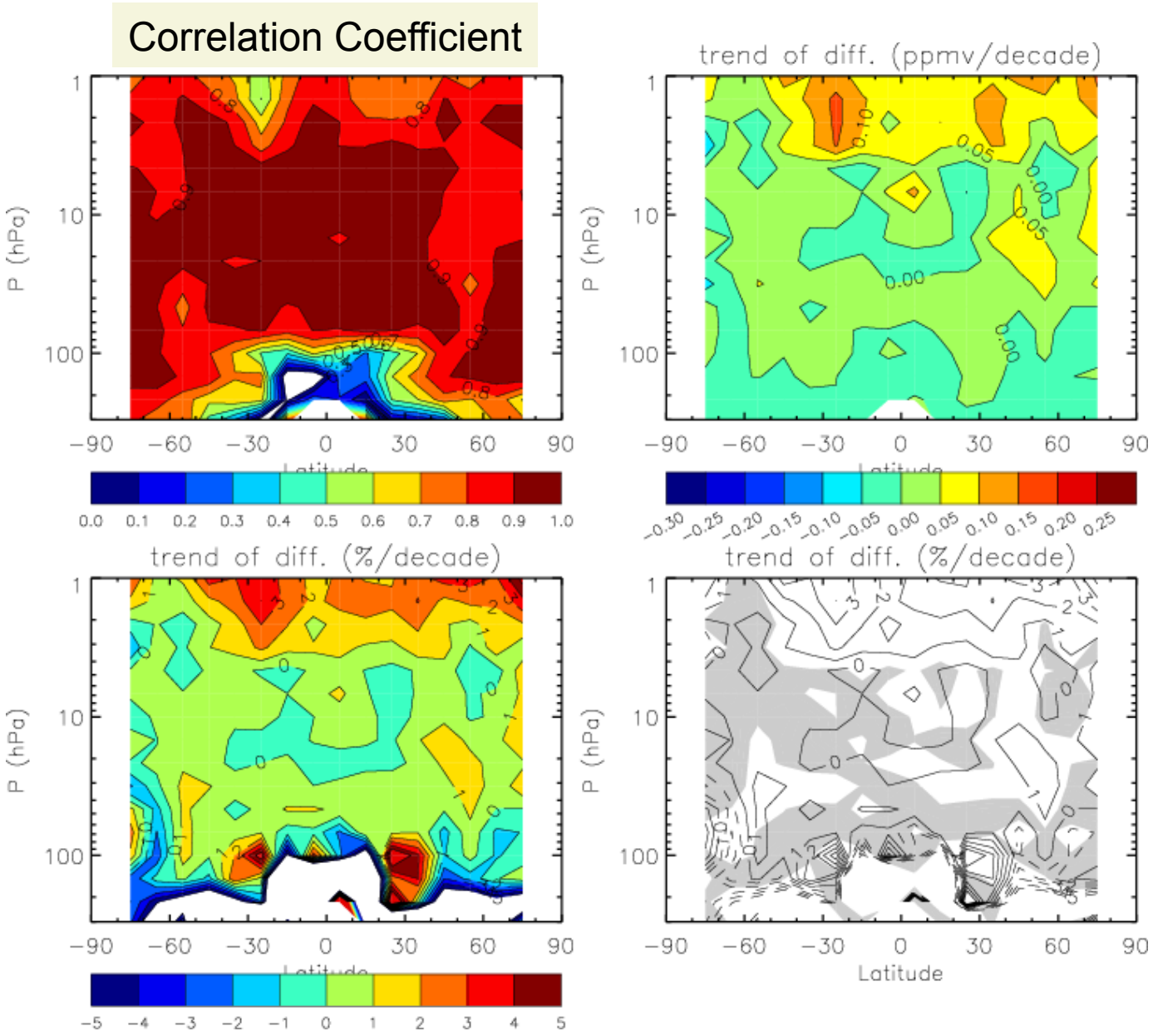
Average differences of zonal means versus averages of coincidences

SAGE II versus Aura MLS Ozone (2004-2005)



- Average offsets are not very dependent on the method used, although some larger differences can exist in more localized latitude bins.
- Diurnal effect plays a role in upper stratosphere / lower mesosphere
  > nighttime Aura MLS values are used above for the coincident method
  - gives better average agreement with SAGE II twilight data

O_3 Comparisons: SWOOSH versus GOZCARDS anomalies (1984 to 2010)



Trend of differences:

< ~1%/dec, p > 3 hPa

2-3%/dec, p < 3 hPa

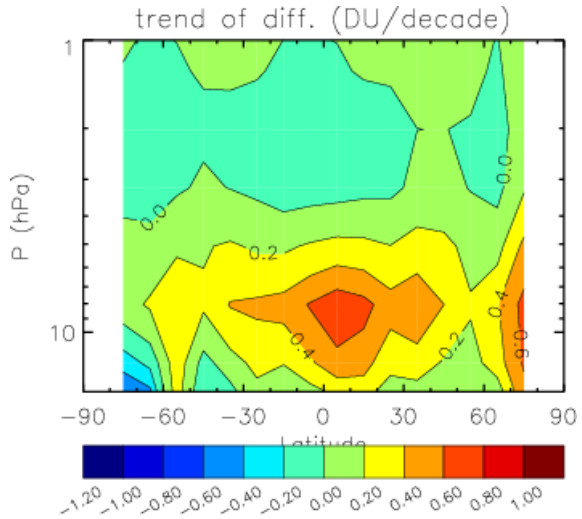
- also larger diffs. in UTLS region

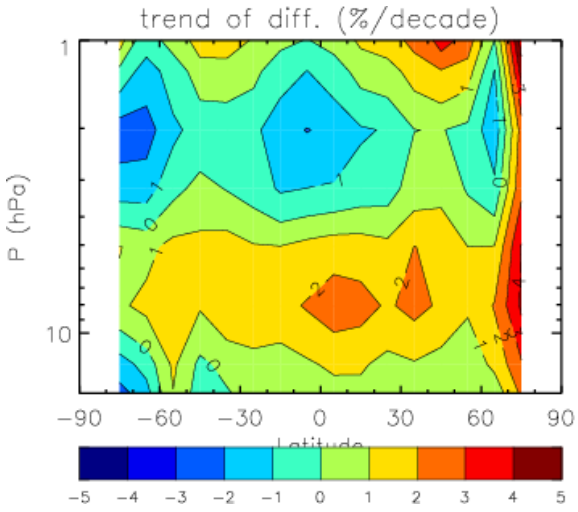
Grey shading indicates where trends are not significantly different from zero (3-sigma test)

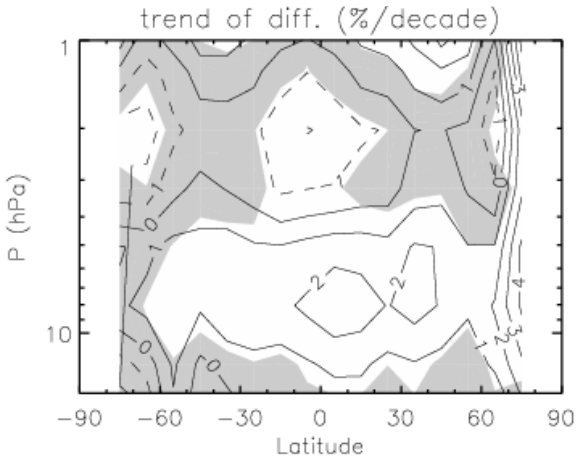
O_3 Comparisons: homogenized SBUV versus GOZCARDS anomalies (1984 to 2010)

NASA Profile MOD *(from R. McPeters, S. Frith, et al.)*

- No offset corrections between different NOAA satellites



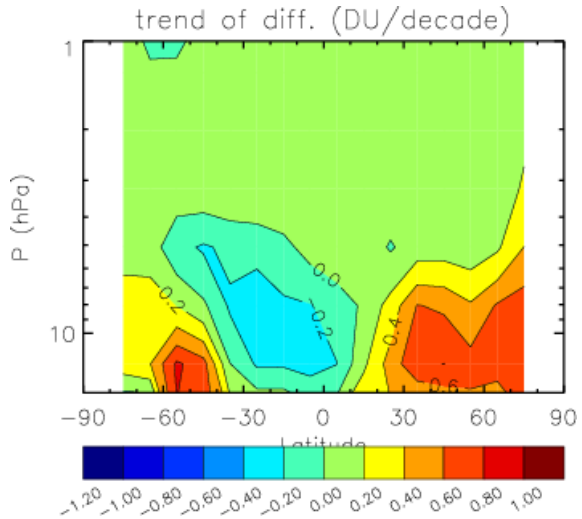


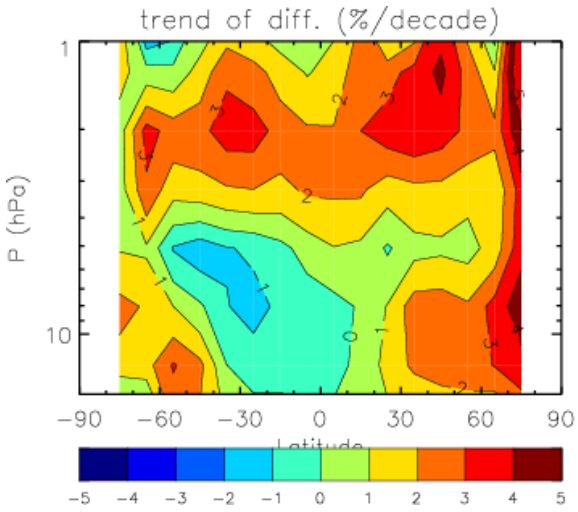


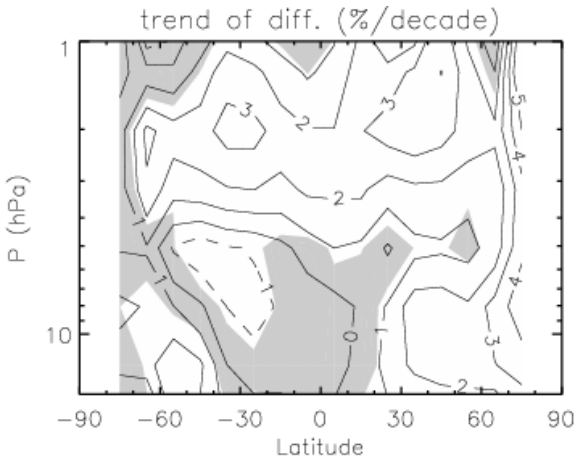
Shading → trends not significantly different from zero (3-sigma test).

NOAA-MA-SBUV *(from J. Wild et al.)*

- Offset corrections are applied between different NOAA satellites



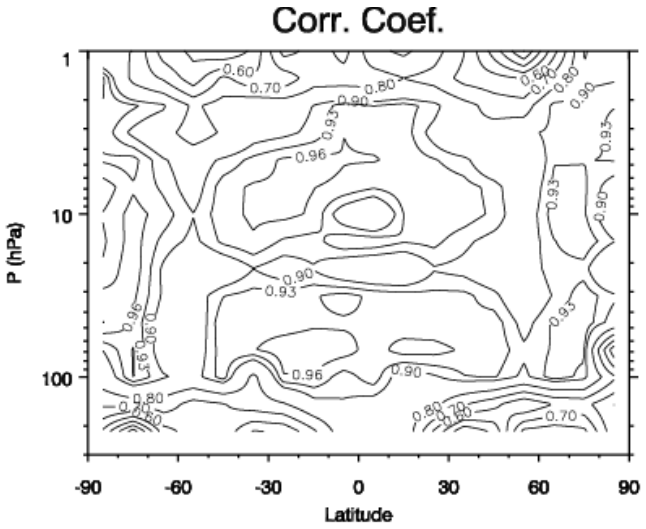




H_2O: Comparisons between GOZCARDS and SWOOSH

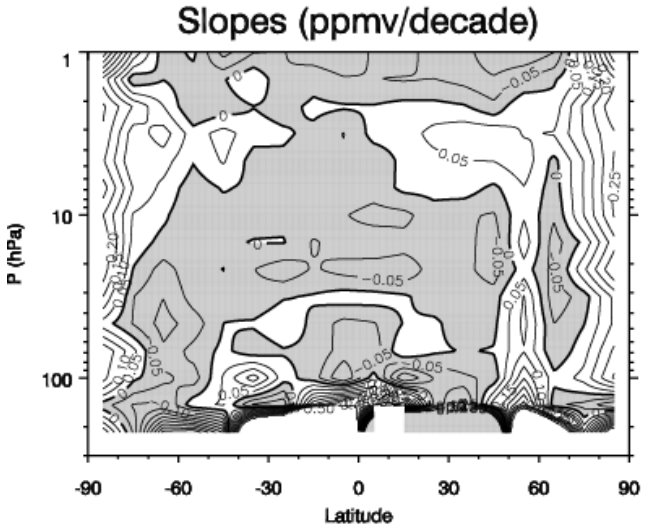
Deseasonalized Anomalies and diffs. (SWOOSH - GOZCARDS)

Note:
mean H_2O differences
for GOZCARDS versus SWOOSH
(not shown here)
are within 5% in most of the stratosphere.

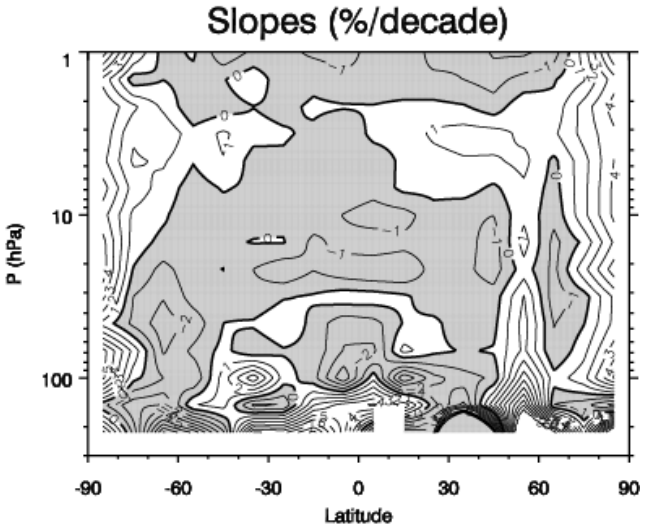


Correlation Coefficients are ~ 0.9 to 0.95 for most of stratosphere
- **degrades somewhat for p < 3 hPa and p > 100 hPa.**

Contours are in 0.1 increments between –0.9. to 0.9 and 0.03 increments thereafter.



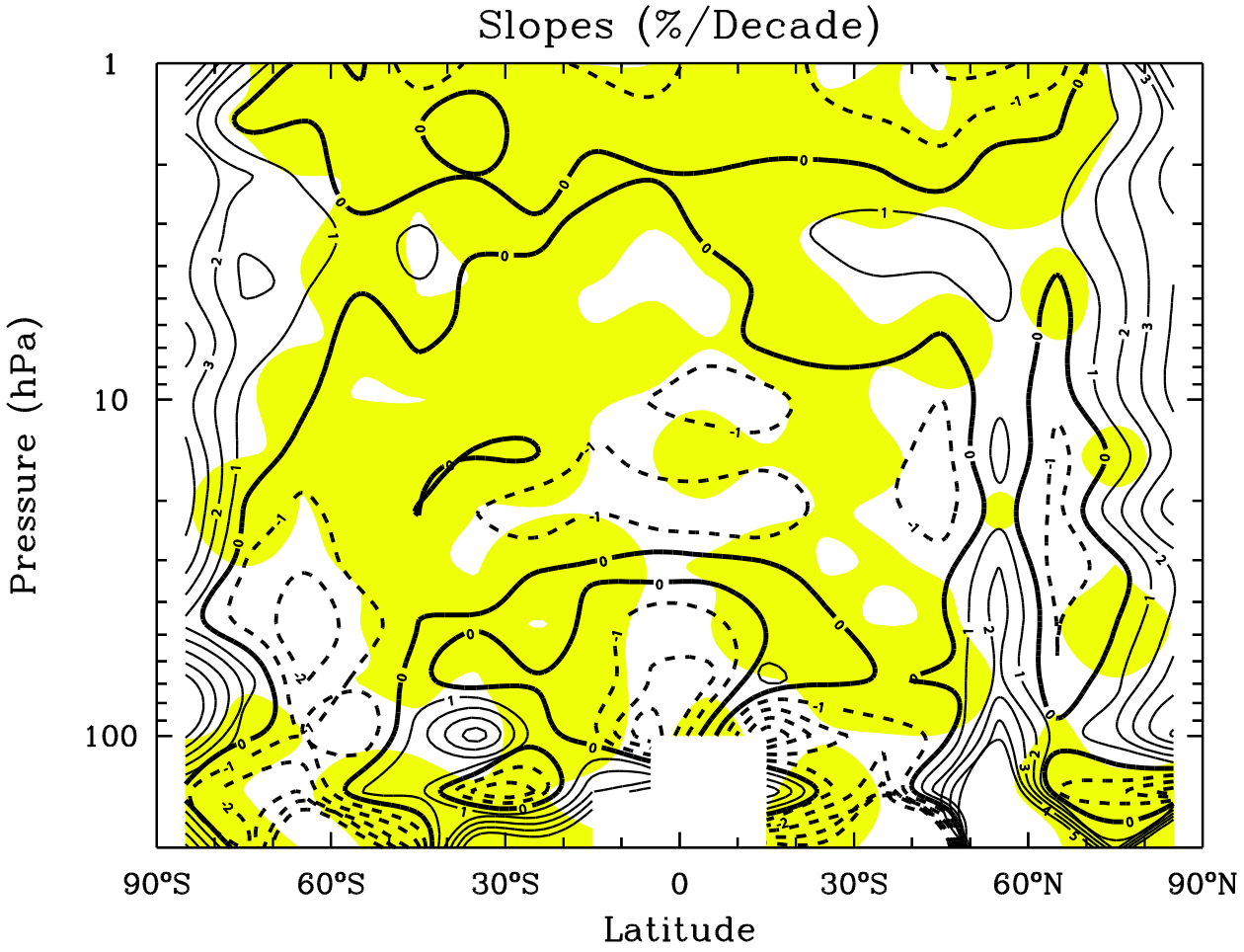
Contours are in 0.05 ppmv/decade increments. Grey shading indicates negative values



Contours are in 1 %/decade increments. Grey shading indicates negative values.

H_2O: Comparisons between GOZCARDS and SWOOSH

H_2O Anomalies (tracking the variability)

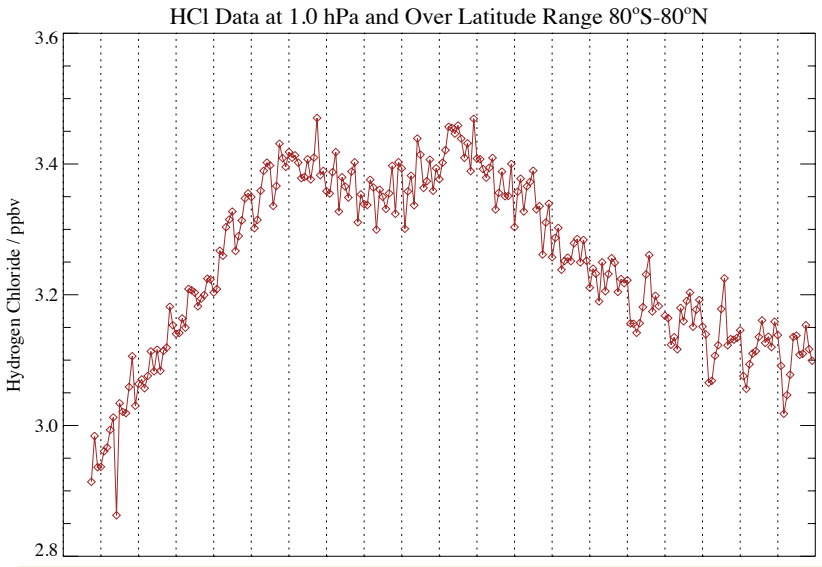


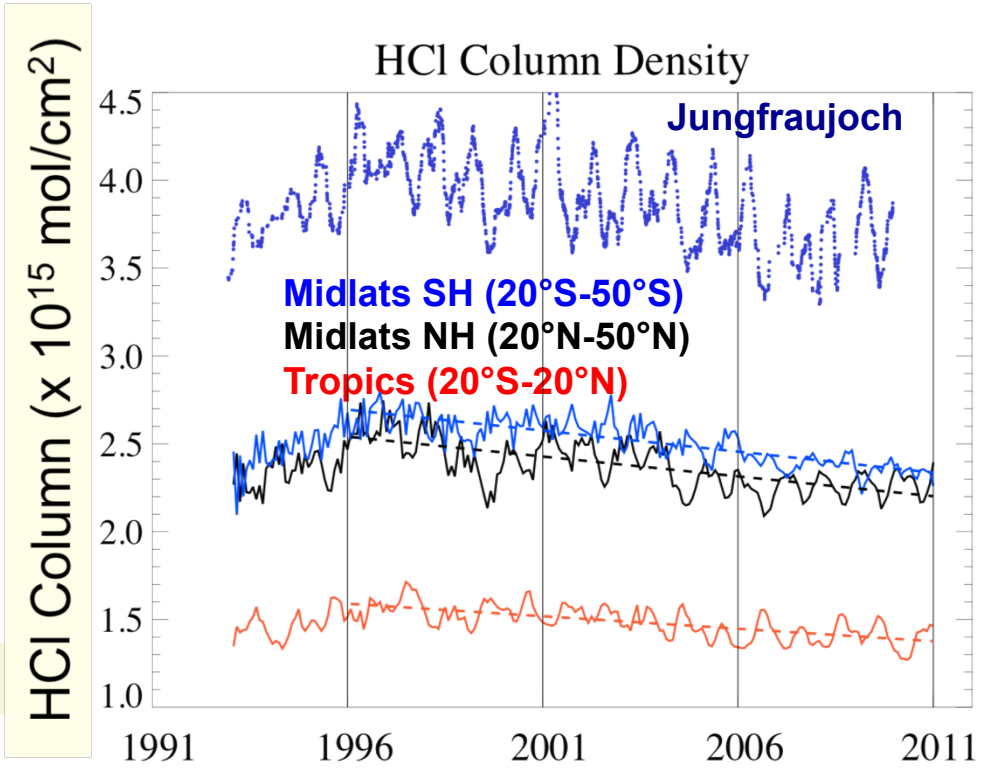
Yellow shading indicates slopes that are not statistically significant at the 3 sigma level. Contours are in 1 %/decade increments.

Temporal variations: A few more examples

(slight amount of interpolation/smoothing applied)

HCl



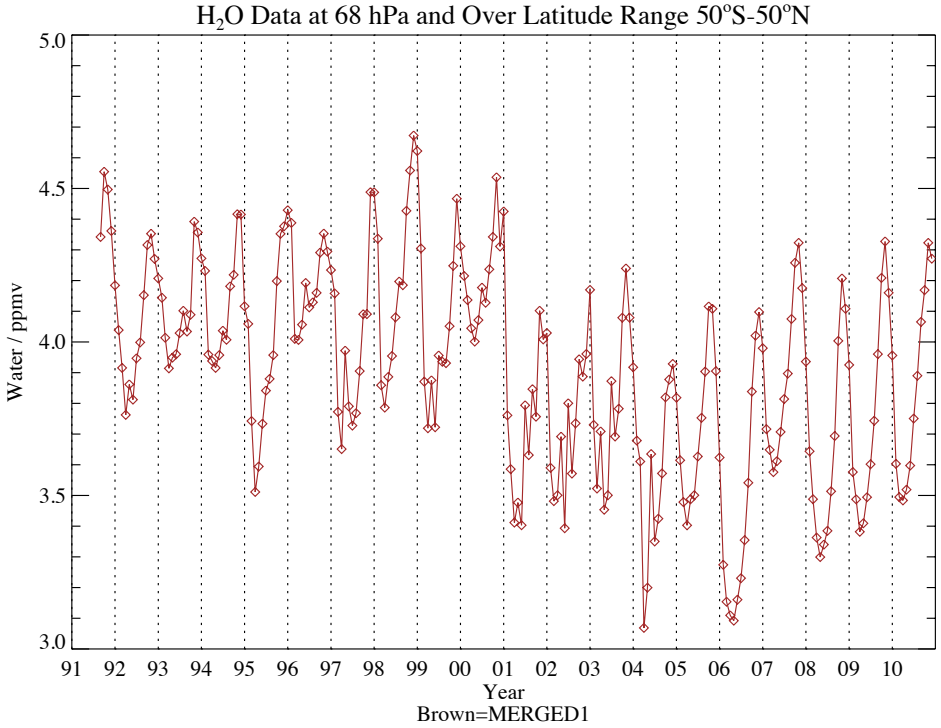


Global merged HCl at 1 hPa (≈ total chlorine)

Witnessing (measuring) the rise and fall of the evil (chlorine) empire…

Column HCl (100 to 1 hPa)
- GOZCARDS trends appear consistent with ground-based total column results (~ - 0.8%/yr)
(**Jungfraujoch** column data shown above)

Temporal variations: A few more examples



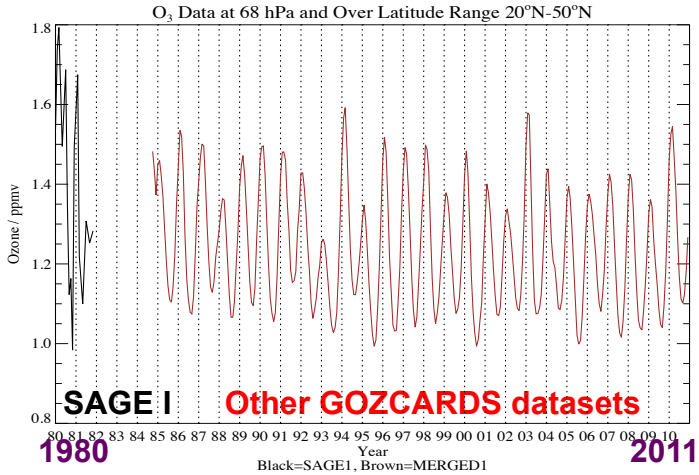
H_2O: interesting LS variations

- as observed/discussed in literature (and at this meeting)
- but will the post-2004 rise continue?

> implications for T, circulation, and climate

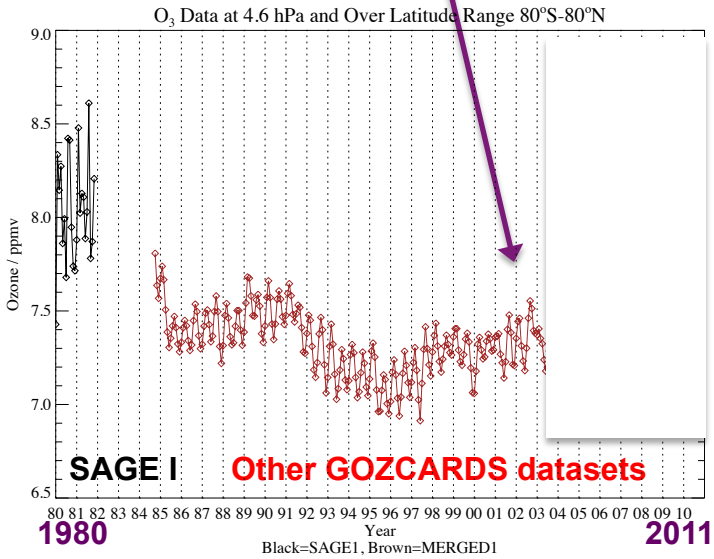
O_3: LS ozone recovery?

- requires detailed analyses



1980 2011

O_3: Is upper stratospheric ozone on its way back up?



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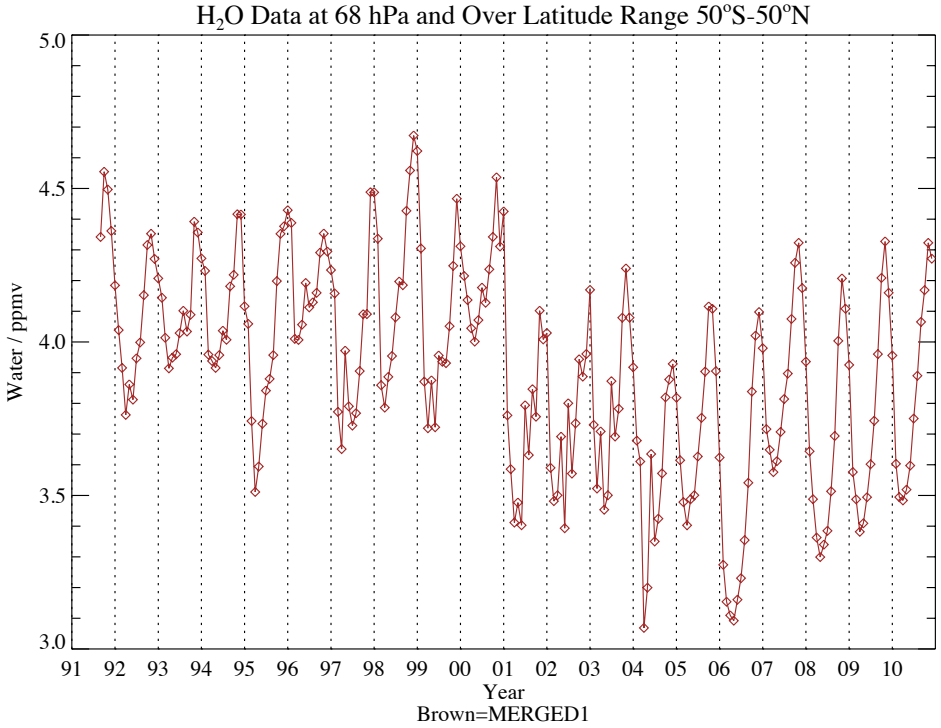

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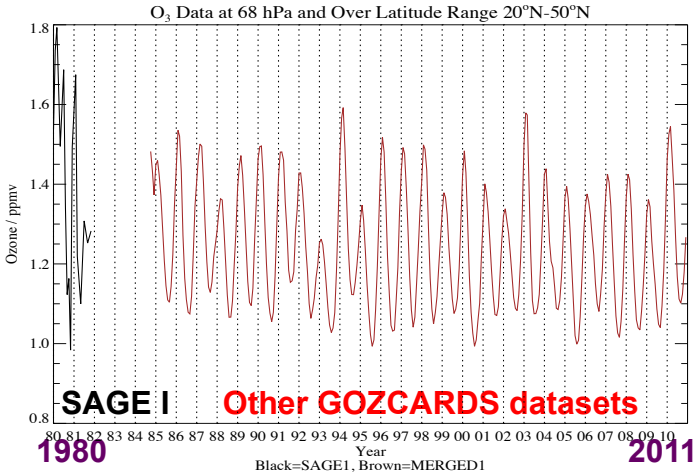

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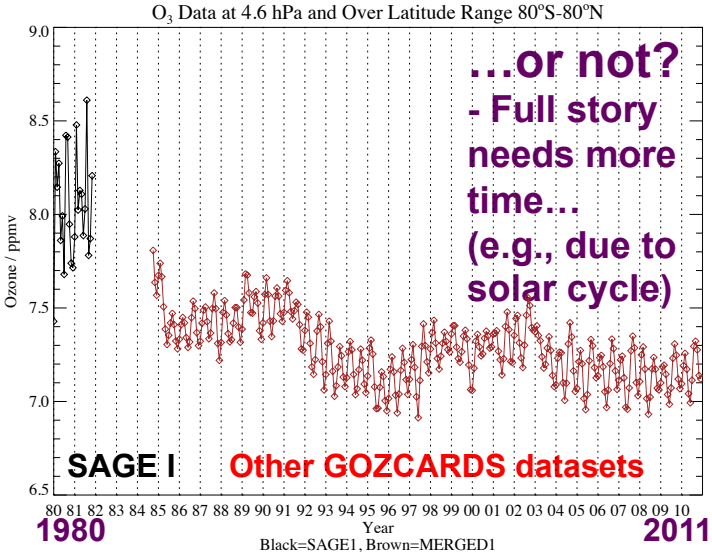


1980 2011

GOZCARDS Status, Upcoming Work

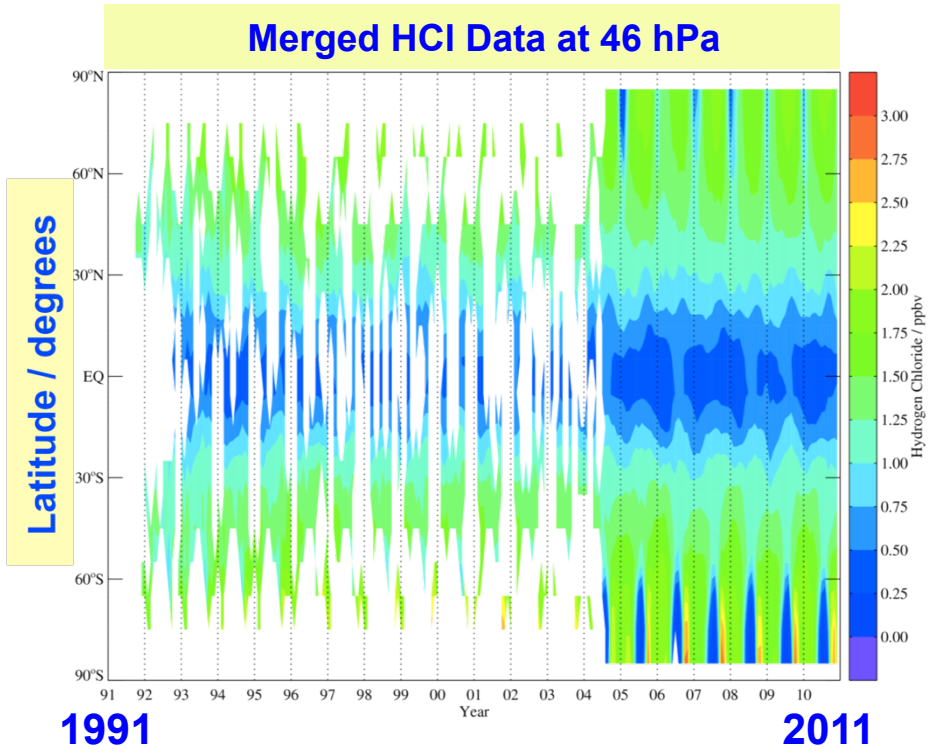
- Deliver HCl, O_3, H_2O, & T (MERRA) to GES DISC for access (starting this month)
- Write overview paper + GES DISC README guide (latter is essentially done)
- Continue GOZCARDS work on other species

  HF, ClO, HNO_3, CH_4, N_2O, NO_2, NO, ClO_x, NO_x

  > some involve fewer instruments (may seem simpler, but also get less overlapping data)

  > each species poses its own challenges

  A lesson for the future: especially for occultation data (e.g., SAGE or ACE follow-on), good to have > 2 years of overlap with ongoing missions (if possible…)



- We expect community feedback, once GOZCARDS goes public
  → some iteration possible
- GOZCARDS data records are generally as close as possible to the original data (after screening, despiking,…)
  → there are (sometimes large) data gaps
- Users may want to smooth or fit data in different ways → trends, etc… (e.g., for SI²N)
  > 'smart' sampling of models is useful
- Short-term portions of the series are only as good as the input datasets, but a long-term carefully produced ESDR should empower the user community to pursue further research.